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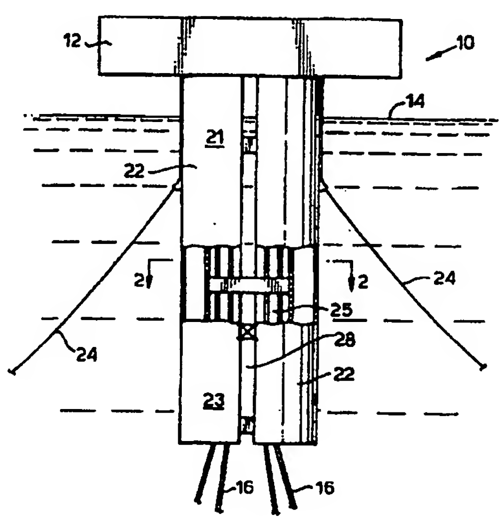
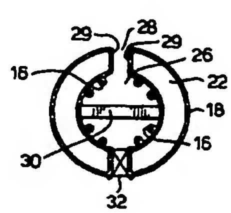
(54) Title: SPAR PLATFORM WITH VERTICAL SLOTS

(57) Abstract

The present invention is a spar platform (10) having a deck (12) supported by a buoyant tank assembly (22) having a buoyant chamber outside wall (18) and a buoyant chamber inside wall (20) which defines a vertically extending open moonpool (26). A plurality of buoyant chamber side walls connect the buoyant chamber inside and outside walls and defining a plurality of vertical slots (28). A counterweight and a counterweight spacing structure depend from the buoyant tank assembly.





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SPAR PLATFORM WITH VERTICAL SLOTS

The present invention relates to a heave resistant, deepwater platform supporting structure known as a "spar." More particularly, the present invention relates to reducing the susceptibility of spars to drag and vortex induced vibrations ("VIV").

Efforts to economically develop offshore oil and gas fields in ever deeper water create many unique engineering challenges. One of these challenges is providing a suitable surface accessible structure. Spars provide a promising answer for meeting these challenges. Spar designs provide a heave resistant, floating structure characterized by an elongated, vertically disposed hull. Most often this hull is cylindrical, buoyant at the top and with ballast at the base. The hull is anchored to the ocean floor through risers, tethers, and/or mooring lines.

Though resistant to heave, spars are not immune from the rigors of the offshore environment. The typical single column profile of the hull is particularly susceptible to VIV problems in the presence of a passing current. These currents cause vortexes to shed from the sides of the hull, inducing vibrations that can hinder normal drilling and/or production operations and lead to the failure of the anchoring members or other critical structural elements.

Helical strakes and shrouds have been used or proposed for such applications to reduce vortex induced vibrations. Strakes and shrouds can be made to be effective regardless of the orientation of the current to

the marine element. But shrouds and strakes materially increase the drag on such large marine elements.

Thus, there is a clear need for a low drag, VIV reducing system suitable for deployment in protecting the hull of a spar type offshore structure.

In accordance with the invention there is provided a spar platform comprising:

a deck;

a buoyant tank assembly, comprising:

a buoyant chamber outside wall;

a buoyant chamber inside wall defining a vertically extending open moonpool;

a plurality of buoyant chamber side walls, connecting the buoyant chamber inside and outside walls and defining a plurality of vertical slots in the buoyant tank assembly;

a counterweight; and

a counterweight spacing structure.

The invention will be described further in more detail by way of example and with reference to the accompanying drawings in which:

FIG. 1 is a side elevational view of a spar platform in accordance with the present invention;

FIG. 2 is a cross sectional view of the spar platform of FIG. 1, taken at line 2-2 in FIG. 1;

FIG. 3 is a side elevational view of another alternate embodiment of a spar platform in accordance with the present invention;

FIG. 4 is a cross sectional view of the spar platform of FIG. 3, taken at line 4-4 in FIG. 3;

FIG. 5 is a cross sectional view of the spar platform of FIG. 3, taken at line 5-5 in FIG. 3;

FIG. 6 is a side elevational view of yet another alternate embodiment of a spar platform in accordance with the present invention; and

FIG. 7 is a cross sectional view of the spar platform of FIG. 6, taken at line 6-6 in FIG. 6.

In the figures like reference numerals relate to like components.

FIGS. 1 and 2 illustrate one embodiment of the present invention. Here spar 10 presents a deck 12 above ocean surface 14. Deck 12 is supported at the top of spar hull 22. The hull is elongated and vertically oriented with a buoyant top section and a ballasted lower section. The hull has an outside wall 18 and an inside wall 20. The inside wall defines a moonpool 26.

A plurality of mooring lines 24 are connected to a spread of anchors (not shown) set in the ocean floor to help hold spar 10 in place over wells or subsea manifolds (not shown). In other embodiments, a plurality of risers 16 may act alone as tethers to form the anchoring system securing hull 22 in place while providing conduits for conducting produced oil and gas.

Risers 16 extend from the ocean floor to the deck for conducting well fluids from wells or subsea manifold. The upper end of risers 16 are connected to production facilities supported by deck 12 and, after initial treatment, the hydrocarbons are directed through an export riser to a subsea pipeline, not shown. In this embodiment, risers 16 are arranged within moonpool 26 along the interior periphery of hull 22. See also FIG. 2.

Spar 10 is resistant to heave motions and has an elongated, vertically oriented hull 22 which is buoyant at the top, here buoyant tank assembly 21, and is

ballasted at its base, here counterweight 23, which is separated from the top through a middle or counterweight spacing structure 25 . Such spars may be deployed in a variety of sizes and configuration suited to their intended purpose ranging from drilling alone, drilling and production, or production alone.

A basic characteristic of the spar type structure is its heave resistance. However, the typical elongated, usually cylindrical hull or caisson 22 is very susceptible to vortex induced vibration ("VIV") in the presence of a passing current. These currents cause vortexes to shed from the sides of the hull 22, inducing vibrations that can hinder normal drilling and/or production operations and lead to the failure of the risers, mooring line connections or other critical structural elements. Premature fatigue failure is a particular concern.

Prior efforts at suppressing VIV in spar hulls have centered on strakes and shrouds. However both of these efforts have tended to produce structures with having high drag coefficients, rendering the hull more susceptible to drift. This commits substantial increases in the robustness required in the anchoring system. Further, this is a substantial expense for structures that may have multiple elements extending from near the surface to the ocean floor and which are typically considered for water depths in excess of half a mile or so.

The present invention employs a plurality of vertical slots 28 through the buoyant tank assembly 22 which are defined by side walls 29 connecting inner wall 20 and outer wall 18. Slots 28 are aligned in pairs on opposing sides of hull 22. These paired slots allow current to

pass through the spar hull to the moonpool and out again, thereby reducing drag and preventing the highly correlated flow around the hull which leads to VIV problems. The size of the slot, its orientation and configuration may be determined by the specific application. For instance, effectiveness may be increased across a greater angle of attack by the current by beveling, or double beveling the relative orientation of side walls 29 which conduct current through spar 10.

In the embodiment of FIGS. 1 and 2, the vertical slots are aligned to bisect the hull with a flow path directly through the centre of the moonpool and extend substantially the entire length of hull 22. Slots of this length provide an opportunity to pass risers 16 from an auxiliary drilling and completion vessel (not shown) to the moonpool within the spar. This facilitates use of a smaller, production only spar platform. However, slots of this length may raise particular needs for structural reinforcement. Here a plurality of beams or struts 30 are deployed to join the respective halves of the bisected spar hull 22. Such beams may be used with minimal interference to direct drilling and workover support through the use of auxiliary vessels. Alternatively, removable struts 32 may join across slots 28 intermittently along the slots. Struts 32 may be removed for riser passing operations. Further, beams 30 and/or removable struts 32 may be formed from substantially open space frames or presented in a streamlined configuration to minimize obstruction.

This reinforcement may be particularly important where more than one pair of slots 28 are deployed. This may be desired to accommodate misalignment of the current to the nominal design orientation. Further, some

locations may have secondary as well as primary design nominal current orientations, e.g., prevalent seasonal shifts.

However, vertical slots 28 need not extend the entire length of hull 22 in order to provide significant drag reduction and VIV suppression. See, e.g., the alternate embodiments of FIGS. 3 and 6. FIGS. 3-5 illustrate an embodiment having two pairs of vertical slots 28A and 28B, here arranged with different azimuth orientations represented by arrows 34 in FIG. 4. Each pair is horizontally aligned, but the pairs need not be on the same level, nor of the same orientation. The two levels here can provide for greater deviation from the nominal design current orientation. Alternatively, a given location may be routinely be subjected to different prevailing currents as a function of depth in the water column. In the later circumstance, different prevailing currents could be optimally addressed with paired vertical slots 28 deployed at various levels which are designed for the orientation, magnitude, and projected variance expected along the spar hull. Note also the riser placement in FIG. 4. Risers too, may be subjected to VIV and the need for VIV suppression within the hull may be controlled by positioning the risers out of alignment with the current path through the moonpool.

Also asymmetrically connected mooring lines may be used to reorient the spar in response to deviations in the current.

FIG. 6 illustrates a configuration of the present invention in which the buoyant tank assembly 21 alone is the hull 22 which defines a buoyant chamber with a pair of slots 28 extending therethrough. A truss or open space frame provides a low drag counterweight spacing

structure 25 connecting counterweight 25 to buoyant tank assembly 21. Further, it should be noted that the moonpool need not be circular, e.g., it may be square or rectangular and the current path may laterally or diagonally bisect the moonpool.

Other modifications, changes, and substitutions are intended in the foregoing disclosure, and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the invention herein.

CLAIMS

1. A spar platform comprising:
a deck;
a buoyant tank assembly, comprising:
a buoyant chamber outside wall;
a buoyant chamber inside wall defining a vertically extending open moonpool;
a plurality of buoyant chamber side walls, connecting the buoyant chamber inside and outside walls and defining a plurality of vertical slots in the buoyant tank assembly;
a counterweight; and
a counterweight spacing structure.

2. The spar platform in accordance with claim 1, wherein the vertical slots are arranged on opposite sides of the buoyant tank assembly and are aligned through the centre of the moonpool.

3. The spar platform in accordance with claim 2, wherein two said vertical slots are provided and the vertical slots run substantially the length of the buoyant tank assembly.

4. The spar platform in accordance with any one of claims 1-3, further comprising a plurality of removable struts connected across the vertical slots to allow passage of substantially unimpeded current flow when in place and to allow riser passage into the moonpool when temporarily removed.

5. A spar platform in accordance with any one of claims 1-4, further comprising a plurality of struts

interconnecting the buoyant tank assembly across the substantially open moonpool.

6. The spar platform in accordance with claim 2 or 3, wherein the vertical slots are arranged in a plurality of horizontally aligned pairs, the vertical slots of each pair being arranged on opposite sides of the buoyant tank assembly and aligned through the centre of the moonpool.

7. The spar platform in accordance with claim 6, wherein the horizontally aligned pairs of vertical slots are arranged across a plurality of azimuthal orientations.

8. The spar platform substantially as described hereinbefore with reference to the drawings.

Fig.1.

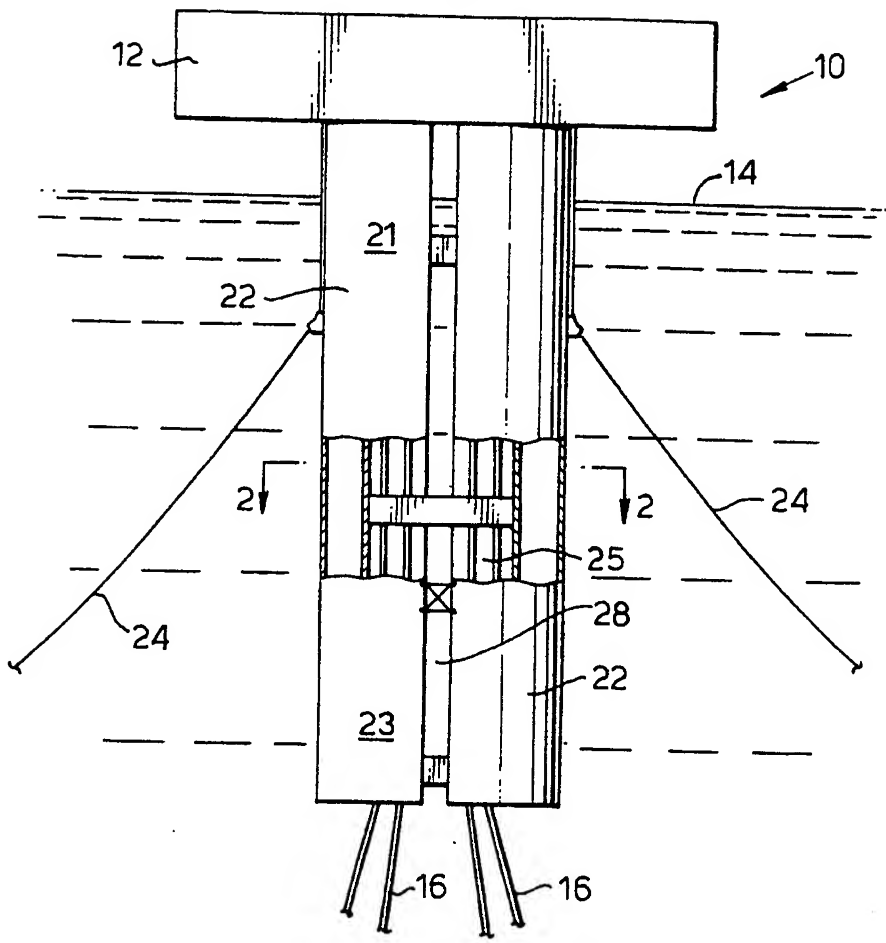


Fig.2.

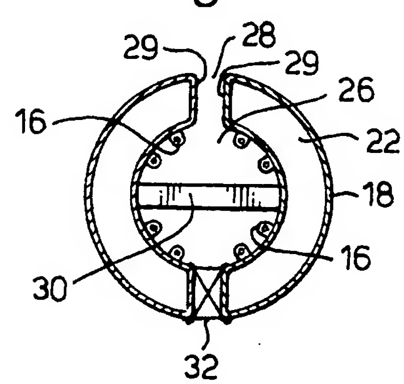


Fig.3.

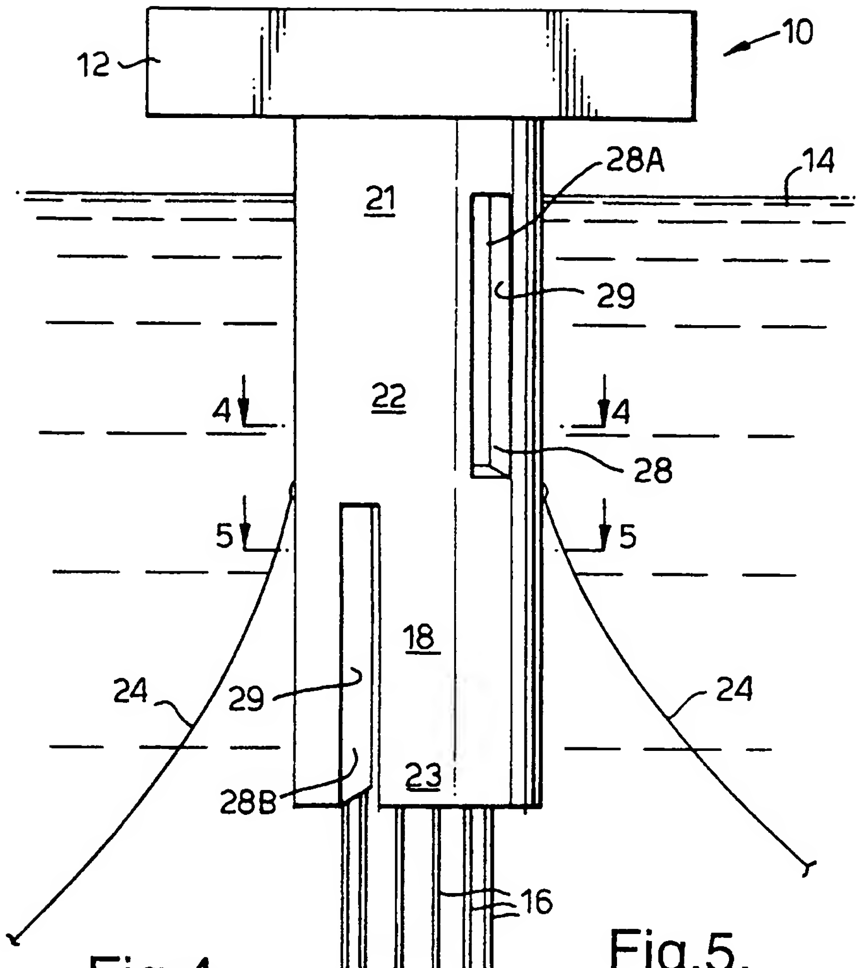


Fig.4.

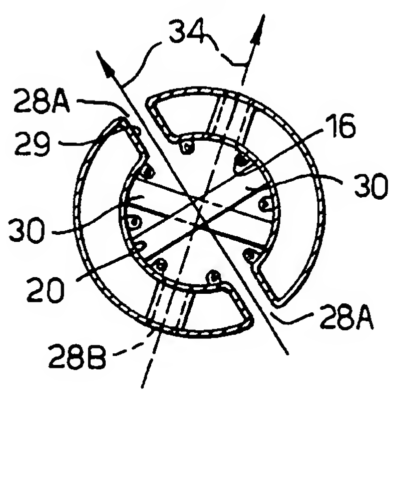


Fig.5.

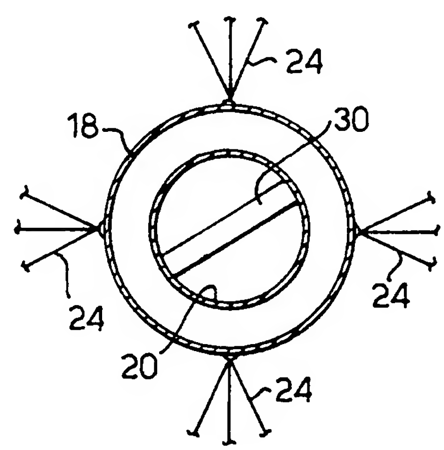


Fig.6.

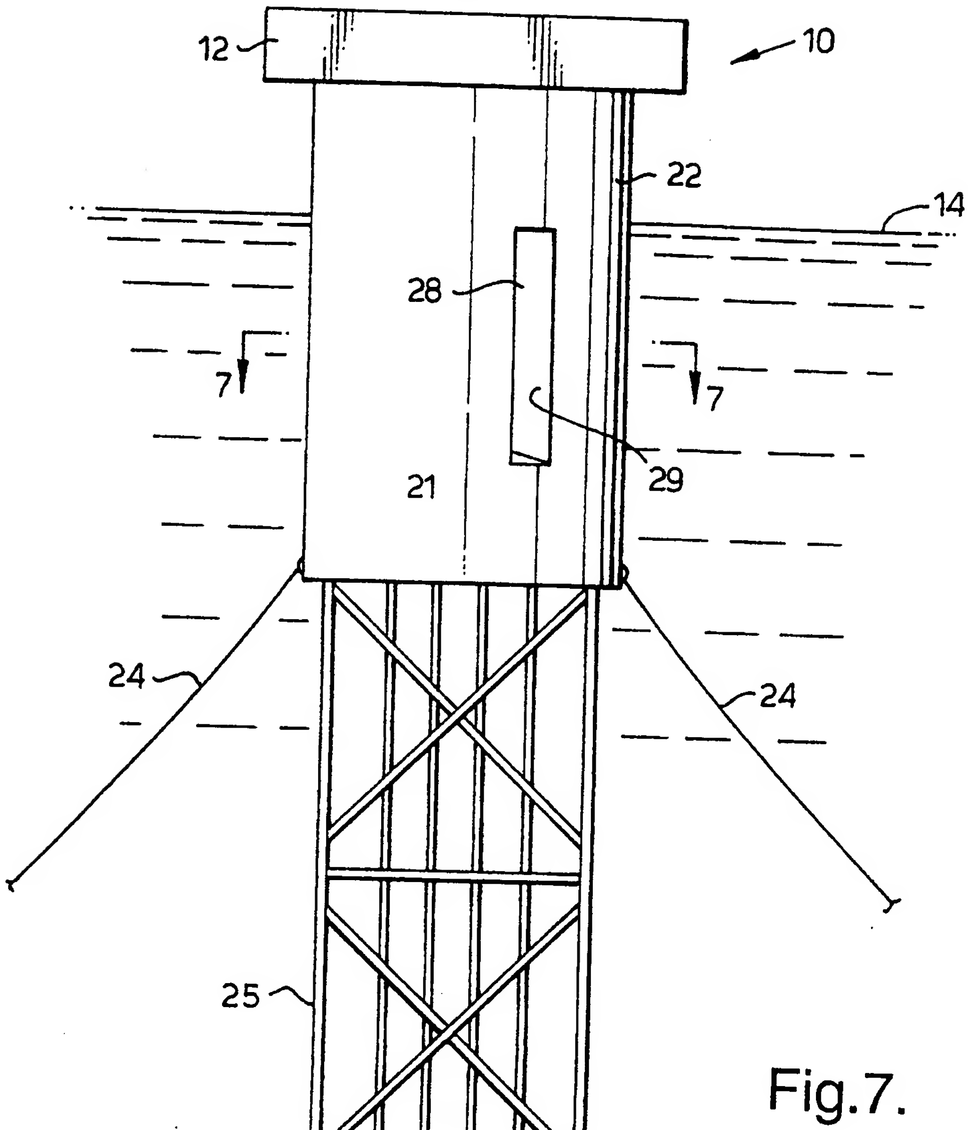
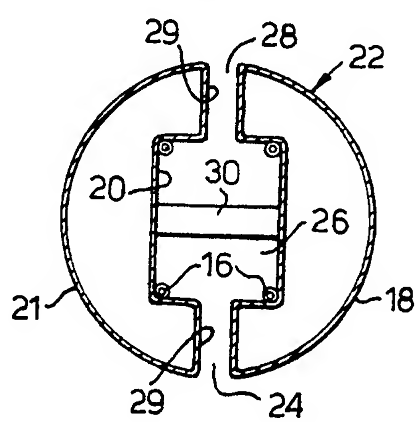


Fig.7.



INTERNATIONAL SEARCH REPORT

Int. ional Application No
PCT/EP 97/07325

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B63B39/00 B63B35/44 E21B17/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B63B E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of box C.

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8 May 1998	15/05/1998

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Information on patent family members

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